

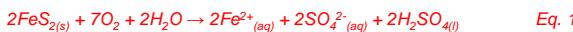
Biological Monitoring of Macroinvertebrate Communities to Assess Acid Mine Drainage

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Introduction

• Acid Mine Drainage (AMD) occurs when pyrite and other sulfide minerals associated with metal deposits and coal seams are exposed to water and oxygen. A series of chemical reactions may result in highly acidic mine water discharges and elevated concentrations of sulfate and dissolved metals (DeNicola and Stapleton, 2002):



• Downstream of AMD discharges, where acidity is neutralized by dilution or buffering, increased oxidation can cause the precipitation of metal hydroxides onto the stream substrate (Fig. 1 and 2) (McKnight and Feder, 1984):



• AMD and its effects on the riverine environment can alter the abundance, taxa richness, diversity, and species composition of aquatic communities (Cherry et al, 2001; Malmqvist and Hoffsten, 1999; Gurrieri, 1998).

• Periodic water quality sampling alone may not accurately reflect acute changes in the frequency and range of pollutants released from AMD sites. Thus, biological monitoring is an additional management tool for assessing AMD discharges and their short- and long-term impacts on riverine ecosystems.

• This study examines the effects of AMD on aquatic geochemistry and macroinvertebrate community structure in over 300 watersheds of the western United States included in the US EPA's Environmental Monitoring and Assessment Program (EMAP-West).



Figure 1. Acid mine drainage and precipitation of iron hydroxide in Clear Creek, CO (USGS)



Figure 2. Acid mine drainage from the Leviathan Mine, Sierra Nevada, California

Study Objectives

1. Examine the effects of AMD on aquatic geochemistry and macroinvertebrate community structure in selected streams of the western United States
2. Develop a better understanding of the role of biological monitoring in integrated water quality assessment

Methods

• 333 sites included in this study are part of the EMAP-West 2000 and 2001 pilot project covering the states of Arizona, California, Colorado, Idaho, Montana, Nevada, North Dakota, Oregon, Utah, South Dakota, Washington and Wyoming, comprising USEPA Regions 8, 9 and 10.

• Benthic macroinvertebrates were collected according to the EMAP-West protocol for Targeted Riffle Samples (see handout for details)

• Water chemistry data were collected according to the EMAP-West protocol for Wadeable Streams (see handout for details)

• Statistical significance at the 98% confidence interval was determined by an independent samples t-test

Results and Discussion

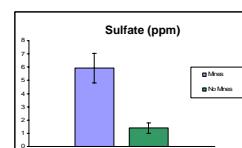


Figure 3. Graph of sulfate concentrations comparing sites with and without mines upstream.

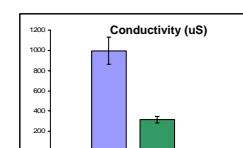


Figure 4. Graph of conductivity comparing sites with and without mines upstream.

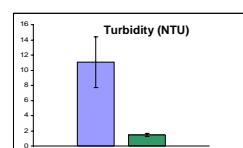


Figure 5. Graph of turbidity comparing sites with and without mines upstream.

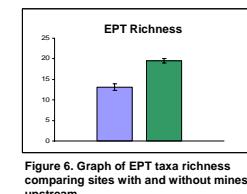


Figure 6. Graph of EPT taxa richness comparing sites with and without mines upstream.

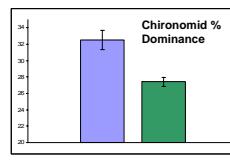


Figure 7. Graph of Chironomid percent dominance comparing sites with and without mines upstream.

• Acid mine drainage can cause physical, chemical, and biological changes in the aquatic environment. The primary compounds released by AMD are sulfate (SO_4) and trace metal ions (Equation 1) (DeNicola and Stapleton, 2002). In this study, sulfate concentrations are approximately 6 times higher at sample sites downstream of mines, compared to sites that are not downstream of mines (Fig. 3).

• Conductivity is approximately 3 times higher at downstream stations, indicating an overall increase in dissolved metal concentrations (Fig. 4).

• Acid mine drainage can also cause the precipitation of metal hydroxides onto the stream substrate (Equation 2) (McKnight and Feder, 1984). In this study, turbidity is approximately 6 times higher at sites downstream of mines, partially due to resuspended flocculent particles in the water column (Fig. 5).

• The geochemical impacts of AMD can be detrimental to acid/metal-intolerant organisms, such as some Ephemeroptera, Plecoptera, and Trichoptera (EPT). Thus, EPT metrics are often used as a measure of intolerance to contaminants (Malmqvist and Hoffsten, 1999). This study shows a significant reduction (approx. 20%) in EPT richness at sites downstream of mines (Fig. 6).

• With less competition for food and other resources, a few tolerant organisms dominate the community structure at polluted stations, seen here by the increased dominance of Chironomid taxa at affected sites (Fig. 7) (Gurrieri, 1998).

• Although the AMD detected at most downstream stations was not severe enough to eliminate the entire benthic invertebrate population, significant changes in community metrics suggest that there is moderate ecological disturbance downstream of abandoned mines in many Western rivers.

Conclusion

• Acid mine drainage affects the geochemistry and community structure of many riverine ecosystems in the western United States.

• Biological monitoring of macroinvertebrate populations can be a valuable tool for identifying and assessing the impacts of AMD on aquatic systems.

• AMD is a global problem, and effective mitigation requires co-operation across a diverse array of scientific disciplines and regional/national authorities (Fig. 8).



Figure 8. Acid mine drainage, Andes Mountains, Peru (USGS)

Works Cited

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